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ABSTRACT

The shifting emphasis in the field of physical education from exercise physiology to motor learning to biomechanics over the past several decades presents a challenge for shaping the future of physical education. The primary challenges involve matching the supply of graduates to the demand for their services, developing a sound philosophy relative to sponsored research, and improving the quality of undergraduate teaching. (DS)

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The Challenge of Change for Physical Education in the 1980's: A Biomechanical Viewpoint

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The Past

Biomechanics has existed as an area of scientific study for more than a hundred years--albeit without that name until very recently. The Biomechanics of Sport--a component of the parent discipline--might be said to have existed for a similar length of time because some of the very earliest work dealt, at least in passing, with sports movements. Such a claim would be somewhat misleading, however, for it was not until the pioneering works of Fenn[7,8] and Hill[17-19] on the mechanics of running in the late 1920's-early 1930's and those of Cureton[2-6] and Karpovich[20-24] on the mechanics of swimming over the next decade, that the first major contributions to our knowledge of the biomechanics of sport were made.

Even after this relatively late start, the field was very slow in developing and it was not until the 1950's that further major contributions were made. Among those were the fine studies of Alley[1] on propulsion and resistance in swimming, Henry[14-16] on the mechanics of sprint starting and Selin[25] on the aerodynamics of the pitched baseball. The studies of Ganslen[9-13] on the mechanics of the pole vault and on the aerodynamics of javelin and discus flight are also deserving of mention.

The present state of the field owes much to events that took place in the mid-1960's. At that time, several departments of physical education with strong graduate programs decided to replace the existing cafeteria-like structure of the Ph.D. degree--a structure in which students moved down the education line taking a little bit of a lot of things--with one in which students were required to specialize in one or two of the component areas of physical education.

In the course of events which followed this decision, the area of exercise physiology was the first to receive emphasis. New exercise physiology positions

were created, advertised and filled; new labs were developed; new courses were introduced; Ph.D. students were recruited and trained; research activity flourished; and associations were formed, meetings conducted and journals produced to disseminate the newly acquired knowledge. In due course, this period of rapid growth came to an end as the supply of Ph.D.'s with a specialization in exercise physiology rose to meet, and eventually surpass, the demand for such people.

By this time, however, the emphasis in the development of graduate programs had shifted from exercise physiology to motor learning. The sequence of events that characterized the development of the motor learning area closely resembled that followed earlier by exercise physiology and, as in the case of its predecessor, led eventually (and almost inevitably) to the supply of graduates exceeding the demand for their services.

At this point, during the early to mid-1970's, the emphasis shifted once again--this time to biomechanics--and the, by now well-established, sequence of events was again set in motion.

The Present--and the Challenge of the Future

Because this shifting of emphasis to biomechanics has been a relatively recent event, it is pertinent to ask here "Where is the biomechanics of sport at present in the developmental sequence established by its predecessors?" The remainder of this presentation will be devoted to answering this question and in the process, to identifying some of the challenges with which we are likely to be confronted in the 1980's. In the course of this evaluation, specific reference will be made to four areas of major concern--graduate education, research, teaching and the national economy.

Graduate Education. In the last 8 to 10 years, many positions for specialists in the biomechanics of sport have been created and filled. Many graduate programs have been developed--there are, for example, at least a dozen institutions in the U.S. currently offering a doctoral degree with specialization in biomechanics. Students have been recruited for these programs and many of them have completed their doctoral degrees and taken positions in the field. Others--about 35 at a conservative estimate--are currently enrolled and working towards the degree.

These developments in programs and the concomitant increase in the number of qualified graduates have led to a slow, but steady, decline in the number of openings in biomechanics. Indeed, the situation has now reached the point where the supply of graduates matches or exceeds, and will very shortly far outstrip the demand. It is obvious, therefore, that one of the most immediate challenges of the 1980's will be to adjust to the decreasing demand for our graduates.

There are three alternative courses of action that might be taken to meet this challenge--we can decrease the supply, or increase the demand or do both of these things simultaneously.

The supply of graduates can readily be decreased by setting more rigorous standards for admission to, and graduation from, our Ph.D. programs. The consequences of such an action would probably be both good and bad. On the one hand, it should lead to an improvement in the quality of the graduates entering the field and thus, ultimately, in standards within the field itself. On the other, by reducing the number of students in biomechanics programs, it might well create serious difficulties in terms of accountability.

The demand for graduates might be increased--as it has been recently in exercise physiology and, to a much lesser extent,in motor learning--by convincingly

demonstrating to industrial and other non-academic institutions that a Ph.D. in biomechanics has something of value to contribute in these settings. Some progress has already been made in this direction and appointments to non-academic positions are now being made--albeit on a very limited scale. The national economy permitting, the creation of employment opportunities in non-academic settings is likely to increase, at a relatively slow rate, for some time to come. In the final analysis, however, the increased demand for our graduates which such opportunities represent is a short rather than long term solution to the problem of oversupply. Indeed, it might be argued that it is not really a solution at all but simply a means for delaying the onset of the problem.

Another, perhaps less obvious way to respond to the problem of oversupply is simply to act as if the problem did not exist. That is, to blithely ignore the state of the market-place and let our graduates work out their own salvation. This approach ensures a high degree of competition for each position and shifts the onus for quality control from the people who educate students to those who hire them when they graduate. While problems may still arise in the long run, the implicit or active misrepresentation of the job market likely to be involved in such an approach, should ensure a continuing supply of graduate students and thus also delay and minimize problems of accountability. Although we might all wish it otherwise, this approach will no doubt be followed by those who are untroubled by the ethical or moral questions involved--or who simply fail to recognize the state of the market and the existence of these questions.

Research. The changes in positions, programs, and Ph.D.'s over the last 8 to 10 years have naturally been accompanied by changes in research activity

within the field. The volume of research has been substantially increased and there has also been some improvement in quality. Existing societies have made provision for the oral dissemination of research findings and new societies--most notably the American and International Societies of Biomechanics--have been formed for the same purpose. The number of journals which accept papers on the biomechanics of sport has also increased.

The direction that research in the area has taken in recent years has been greatly influenced by two factors--the increased emphasis on participation in physical activity within our society and the steady decline in U.S. performance in international athletics.

An increased public awareness of the beneficial effects of physical fitness has led over the last few years, to huge increases in the number of people who participate regularly in such activities as cycling, tennis, and jogging. Predictably, this upsurge in participation has led to a boom in the sale of related sporting equipment. This, and the industry-encouraged and willingly-accepted notion that one must have the very best equipment available in order to perform well, has resulted in an extensive re-evaluation of the design and construction of many items of sporting equipment and apparel. Sport biomechanists have been very much involved in this process and at the present time are engaged in projects concerned with the optimum design of such items as running and basketball shoes, tennis rackets and weight-training equipment.

The standing of the United States in international athletics--and most noticeably, in the Olympic Games--has been in a state of decline for at least 10 years. This is due in part to a lack of real interest in international athletics, compared to the interest in regional and national com-

petition and, in part, to the basic incompatibility of the present system of athletic governance in the United States with the achievement of success at the international level. It is also believed by some that the decline has been due in part to the lack of a coordinated scientific approach to the selection, preparation and performance of U.S. athletes compared to that now used in many other countries. This belief--firmly held by most biomechanists and others in the exercise sciences--has led to a growing involvement with the analysis of the performances of national and international-level competitors. For example, biomechanists are currently engaged in research--sponsored by national associations--on the performances of top-class athletes in track and field, cycling, kayaking, weight-lifting, cross-country skiing and ski-jumping, among others.

The involvement of biomechanists in these two broad areas--equipment design and evaluation and the performance of top-class athletes--has had both good and bad effects on the field. Among the beneficial effects has been the influx of funds for equipment and for student and faculty support, and the opportunity to develop and demonstrate methods of practical significance. This involvement may also have served to make biomechanists more aware of the gulf that often exists between the scientific data they consider to be so important and the needs of the practitioner for whom it is ultimately intended.

The detrimental effects of our involvement in these areas is a source of some concern. In attempting to solve problems of interest to the manufacturers of sporting equipment, biomechanists have in some instances, conducted studies in which equipment or apparel has been examined in detail and the human being for whose use it is intended has been virtually, or completely, ignored. When biomechanists conduct studies of this nature, one is forced to conclude that

these are studies in mechanics rather than biomechanics and that, as such, they offer little likelihood of advancing our understanding of human motion. Further, it might be argued that, by diverting the efforts of those who are capable of making important contributions to our knowledge in this area, such activity actually has a negative influence.

A somewhat similar problem can arise when biomechanists work with top-class athletes. These athletes and their coaches are generally interested in relatively obvious and simple measures of a performance--the velocities of the athlete or his equipment at critical instants such as touchdown, take-off or release; the lengths and durations of contributing phases such as the times of take-off and flight; and so on. The generation of such data--usually via film analysis--is often very helpful to the coach and his athletes but is very rarely anything more than a trivial contribution to knowledge in the field. Thus, if the work does not go beyond the provision of data of this kind, the biomechanist, wittingly or unwittingly, ceases to function as a researcher and becomes instead an over-qualified technician. Or, to put it in other words, he exchanges has research role for a service one.

In the light of all this, it is clear that one of the challenges of the 1980's will be to strike that balance which maximizes the beneficial effects of our involvement with equipment manufacturers and top-class athletes and minimizes the detrimental ones. In this regard, biomechanists might do well to adopt a policy of not accepting support for research unless solution of the problems of interest to the sponsor constitute a significant contribution to knowledge in the field or unless parallel studies can be devised so that in the process of solving the sponsor's problems, others of genuine interest to biomechanists can be solved simultaneously. The adoption of such a policy

would, I believe, constitute a step in the right direction.

Another characteristic of current research in biomechanics--and one which may in part be due to the factors already mentioned--is the very heavy, indeed almost exclusive, concern with applied questions. Thus, while dozens of biomechanists are actively engaged with research on specific questions of technique in running, swimming, ski-jumping etc., there are very few working on problems of a more basic and thus more general nature. In my view, this is a grossly inefficient way of advancing knowledge in biomechanics--or, indeed, in any other field. If we were to formulate and answer appropriate questions about such things as the optimum coordination of body segments for the production of maximum force and velocity, the optimum relationship between range and rate in cyclic activities etc., we could then apply this knowledge to any activity in which such considerations were relevant. Such an approach would, in my judgement, be infinitely more effective than trying to resolve the same questions within the constraints of a seemingly endless number of specific sports.

Teaching. Teachers of undergraduate kinesiology and biomechanics courses have been subjected to conflicting pressures as a result of recent developments within the field.

The development of biomechanics as an area of specialization has created a demand for graduate students with a strong background in mathematics and the physical sciences. It has also brought demands for changes in the nature and content of the undergraduate course--changes which it is believed will lead to the student being better prepared for advanced study in the area, than he has been in the past. In response to these demands, many teachers have developed undergraduate courses which have a heavy theoretical

basis and which include quite extensive treatment of the research methods used in biomechanics.

At the same time as these changes have been taking place, there has been developing a growing awareness that biomechanics has an important contribution to make in the professional preparation of teachers and coaches. This in turn, has led to demands that the content of the undergraduate course be changed to better reflect the needs of those students--the vast majority in most cases--who are preparing themselves for teaching and coaching careers. In response to these demands, many teachers have developed courses which consist of a bare minimum of theory and as much application of that theory to the problems encountered in practice, as time will permit.

The Kinesiology Academy of AAHPER has been working for some time to resolve the obvious problem posed by these conflicting pressures for change in the undergraduate course. Following the National Conference on the Teaching of Kinesiology conducted at the University of Illinois in the summer of 1977, the Academy set up a task force to prepare a statement on the function, and a set of guidelines on the conduct and content of the undergraduate course. This Task Force reached the conclusion--since endorsed by participants in the annual meeting of the Academy--that the prime function of the undergraduate course is to provide students with the knowledge and experience necessary to conduct useful qualitative analyses.

To this end, the Task Force has recommended that the undergraduate course be divided into three equally-emphasized parts--one devoted to anatomical considerations, one to basic mechanical concepts and one to the qualitative analysis of human movements. The first two of these parts present no major difficulties. Except for possible differences in the topics covered within each part and, in some cases, the equal weighting of the two, they represent

no major departure from the traditional pattern. The third part, in contrast, presents substantial difficulties. While the importance of qualitative analysis in teaching and coaching is widely recognized, there have been very few attempts made to develop a simple, yet rigorous system for conducting such analyses. Furthermore, while they will undoubtedly serve a useful purpose until something better becomes available, those systems which have been developed to date fall far short of what is ultimately required. Under such circumstances, it is obvious that one of the challenges to biomechanics in the 1980's is to develop a thorough and effective system for the qualitative analysis of human movements--a system which can be used to perform simple and accurate biomechanical analyses and to determine what instructions should be given to the performer.

It is firmly believed by the members of the Kinesiology Academy's Task Force, and by many others within the Academy, that adoption of the proposed guidelines for the teaching of the subject at the undergraduate level will result in a substantial elevation in the overall quality of the work done at that level. It should ensure, for example, that students receive a reasonably thorough introduction to both the anatomical and mechanical aspects of human movement--something that would be a decided improvement since many courses taught at the present time emphasize one of these to the almost total exclusion of the other. By making provision for the development of their skills in qualitative analysis, it should also ensure that students are better prepared for their future roles as teachers and coaches than they are at the present time. Although certainly not its principal purpose, the standardization of the content should also serve to minimize the problems currently encountered when students who have taken vastly different undergraduate courses enroll in graduate-level courses in the area.

Securing the widespread adoption of the Kinesiology Academy guidelines is thus one of the challenges which workers in kinesiology and biomechanics will strive to meet in the 1980's.

Economy. Over-riding all challenges to be faced in the 1980's by biomechanics, by physical education, and indeed, by our society at large, is the apparently mounting challenge presented by the state of the economy. A great deal has been said in recent months concerning the state of the U.S. economy and, if one is to believe even half of what one reads and hears, the 1980's seem very likely to be a period of great economic uncertainty.

If the present rampant inflation can be arrested and the external pressures to which our economy is subjected can be substantially reduced--two mammoth tasks--the resulting economic conditions are likely to favor continued growth and development. In this case, it is reasonable to expect that biomechanics will continue to develop along lines similar to those already followed by exercise physiology and motor learning. That is, that the period of rapid growth now approaching an end will be followed by one in which the field gradually attains a measure of maturity. Further, one might expect that the level of maturity attained will be largely dependent on where the major research efforts are focused--on important central questions or on trivial, peripheral ones--and on the extent to which the emphasis shifts from quantity to quality in all areas of activity within the field.

If the inflation and external pressures to which our economy is presently subjected are not substantially reduced, the economic turbulence evident today is likely to be exacerbated. This, of course, would have very serious

effects not only on biomechanics and physical education but on virtually all fields of activity within our society. A marked deterioriation in economic conditions would undoubtedly lead to heavy cutbacks in all areas of biomechanics activity. This, in turn, would force corresponding changes in the nature of these activities. While most of these changes would have a serious, detrimental effect on the work done in the field, it is conceivable that one such change would have a beneficial effect. As appears to have been the case in Eastern Europe, the shortage of funds for equipment and supplies could force researchers to devote more time to identifying the important questions in the field, and to designing simple, crucial experiments to find the answers to these questions, than is presently the case. By thus shifting the emphasis from the power and sophistication of the research tools at our disposal to the ends for which they should be used, an economic setback could actually work to the ultimate benefit of the field. This possible benefit notwithstanding, it is obvious that any pronounced deterioration in the U.S. economy would pose very serious problems for biomechanics in the 1980's--problems over which those in the field would have very little control.

Summary.

There will, of course, be many challenges to be faced in the 1980's. Some of those that will arise in the area of biomechanics--matching the supply of graduates to the demand for their services, developing a sound philosophy relative to sponsored research, improving the quality of undergraduate teaching, and so on--can be predicted with relative ease. These challenges can be met successfully provided those within the field recognize that they exist and take the steps necessary to meet them.

Some of the other challenges which biomechanics might be called upon

to face--and, in particular, those that would arise if there was a serious deterioration in the U.S. economy--are much more difficult to predict. These challenges are also likely to be much more difficult to meet successfully.

Although so much of the future is, as always, clouded with uncertainty, one thing can be said with confidence--the state of the field at the end of the 1980's will depend largely on the nature of the challenges we have to face in the next decade and on the adequacy of our responses to them. Let us hope these challenges are not so severe as to preclude an adequate response.

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